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Appreciation units in high school physics

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APPRECIATION UNITS IN HIGH SCHOOL PHYSICS

Submitted by

Persis Crowell
(A.B. Hollins, 1934)

In partial fulfillment of requirements for the
degree of Master of Education

1936

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INDEX.

		Page
Chapter I	Problem, Procedure, and Purpose	1
Chapter II	Similar Attempts in Related Fields and in Practice	5
Chapter III	Present Inadequacies and Suggested Remedies in Terms of Objectives	10
Chapter IV	The Appreciation Technique	18
Chapter V	Plan of Units - Subject Matter and Presentation	22
Chapter VI	Unit I -- Time	28
Chapter VII	Unit II - Ways of Taking Advantage	39
Chapter VIII	Unit III - Lightning and Static Electricity	52
Chapter IX	Unit IV - Unit V -- The Earth	61
Chapter X	General Recommendations for Use in Teaching	72
Chapter XI	Summary, Conclusions, and Recommendations	76
BIBLIOGRAPHY		79

CHAPTER I - PROBLEM, PROCEDURE, AND PURPOSE

The full title of this thesis might well be stated as appreciation units in high school physics based on practical applications in the home and every-day natural phenomena. That is, the units will deal with parts of the environment which can be explained in terms of the science of physics. The purpose then is to draw a few simple examples from the applications of physics in the home and the easy contacts with natural phenomena, that could be used as basic units in a course to further the appreciation of physics by the students.

The units as presented are not expected to cover a full course in physics but are given as a suggestion and model of what could be done in selecting subject matter and presenting it to the class. The aim is appreciation, not mastery of subject matter. It is not expected that a whole course could be carried out with this type unit but is hoped that this type of material and method of presentation will gradually replace to a considerable degree the old formal text-book method.

The first question a reader might well ask is, why change the present method, or, better still, where has this failed? The answer to this can be generally stated as a failure to determine appropriate objectives or a failure to reach these objectives that have been set forth. In a later chapter these inadequacies and failures will be reviewed and new objectives which these units are intended to meet, set up. It is suf-

ficient to state now that science courses as a whole have failed to take advantage of the accepted high place science has in the world of affairs today.

It is quite generally accepted today that education of any form must not only meet the needs of a particular pupil but must select its subject matter from the every-day experiences, observations, interests and understandings of the particular group of pupils with which it deals. It is obvious then that in setting up any sort of teaching units it is necessary to consider what possibilities there are in the natural environment of the home, community, or industrial world which would not only lend themselves to this treatment but also add to the final aim of education i.e. better living. In other words the subject matter must be chosen to meet generally accepted objectives of education and specifically those of physics, rather than for its adaptability to the units. Before selecting the subject matter then it is important to discover and analyze the objectives of an introductory physics course and the total aims of education.

Having chosen the objectives one hopes to attain in an introductory course and the subject matter which will best meet these, it is necessary to determine the best methods to be used in obtaining appreciations. What is the appreciation technique? The various steps in this technique have been quite fully developed by others and are outlined in a later chapter. The next problem is to devise a form for the units which will

embody these steps and at the same time have a logical usable form for presentation.

The units as set up are not planned as projects or contracts for the pupils' use but are more in the form of detailed lesson plans and notes for the teacher's use. The teacher can follow the order of the units as given but at the same time they are flexible enough to allow for the introduction of additional materials or modification when the teacher feels that the units are not meeting the particular needs of his or her class. Thus, in setting up the units not only are the objectives of physics teaching and the steps of an appreciation technique kept in mind, but the problem of making them adaptable and flexible for actual use in teaching is taken into consideration. The procedure of this thesis then is as follows: We are first interested in what others have done along similar lines to obtain some suggestions on the form of the units as well as to note places where changes seem necessary. Second, The present inadequacies and suggested remedies in terms of the objectives of a physics course on the secondary level are outlined and subject matter selected to meet these aims. The next step will be the outlining of the form of the units to be set up, having first given careful consideration to the appreciation technique. When the form of the units is definitely established we are ready to set up a few units not only to show what can be done but as a start towards a complete set of units to cover all the appreciation material of a first year physics course.

To make these units more worthwhile and to aid those who might use them, a chapter is included at the end, devoted to suggestions as to the presentation of the units.

CHAPTER II - SIMILAR ATTEMPTS IN RELATED FIELDS AND IN PRACTICE

Before going on with the main purpose of the thesis it seems appropriate to give a brief survey of what has been done in similar lines and in practice. This survey does not cover all similar attempts in related fields but is given chiefly to show the type of work which has been done previously, the possible trend of this type of teaching, and to point out where future work seems necessary.

The most comprehensive study of this type comes from a group appointed by the North Central Association for this purpose. (18)* Previous to this study the North Central Association had worked out fairly definite objectives for science courses in general and for each special science, and made an analysis of all literature between 1920 and 1926 on the aims, functions, values, desirable methods, present inadequacies in terms of remedies, the place of laboratory, recitation and demonstration experiments, and desirable content. (19) The committee then tried to formulate a course in keeping with these objectives. The plan of the course is outlined below.

1. Divide course into natural teaching units around applications of physical principles.
2. Select ultimate objectives for each unit which the unit may most naturally be planned to accomplish.
3. Include in each unit outline:

---

* All numbers refer to bibliography at the end.

   a. a list of common activities for all pupils
   b. a list of supplementary suggestive activities for capable pupils
   c. a list of suggested reference books for pupil use
4. Preliminary test for each unit to measure roughly --- knowledge, techniques, attitudes, and habits and skills.
5. A similar final test. (21)

The ultimate objectives of the course were practically the same as the "seven cardinal principles" but the immediate objectives are stated as desired outcomes in terms of skills, knowledges, techniques, and appreciations to be attained. Up to September, 1930 this group had set up 19 units including such units as:

> "What are machines and of what value are they?"
> "Hydrometers as illustrative of the application of the principles and methods of science."
> "Applications of the principles of fluid pressure in water and aircraft."
> "Electric lighting systems."
> "Photography and picture projection." (21), (18), (20)

These units however are not set up with appreciation as the main aim and hence are not presented as the units of this thesis will be. Further, the units are more a syllabus of material to cover, with specific aims for each designated, rather

than a detailed plan for presentation of material. As such they are very useful to a teacher in outlining a course to be given. They could be used as an outline of the material for such units as the ones to be presented here or for a further program of a series of units to cover a full course in introductory physics.

Another study along this line is that of Jesse Clemensen, "Study Outlines in Physics-Construction and Experimental Evaluation." (50) This again is more useful as a basis for setting up units since its chief aim seems to be the putting forth of criteria for the selection and organization of material, the aims of education as applied to physics, and the techniques of the construction of study outlines, although a sample study outline is included.

"The Recitation in a Science-Type Subject", published in School, Science and Mathematics, (28) is a summary of a teacher's effort to give a physics course, the main aim of which was appreciation, and is an example of the appreciation technique in practice. (28) Another similar report is made of an attempt at attaining appreciations in chemistry in "An Attempt to Vitalize Chemistry Through Units." (4)

In the field of chemistry three theses were found which set up teaching units. One of these "Appreciation Units in Chemistry Based on Practical Applications in an Agrarian Community and in the Home" (38) definitely has appreciation as its

chief aim, while the other two "A Course in Chemistry Derived from Problems in Industry" (42), and "The Development of a Non-Preparatory Course in Chemistry as Used in Public High Schools" (15), have practical application and life-situations as their main point of departure but with appreciation as one of the aims in the presentation of their materials.

It is interesting to note, in this connection, that such educational periodicals as School Science, and Mathematics and the Journal of Chemical Education quite frequently contain single units with appreciation as the aim. Most of these are actual reports of units which have been tried.

In Rowland's thesis "History and Trend of the Teaching of Physics in the Secondary Schools of the United States" (40), he points out the increasing tendency toward the teaching of science for appreciation, and the less formal character of courses, stressing practical or industrial applications. As far back as 1920 the Commission on the Reorganization of Secondary Education appointed by the National Education Association recommended that more home, commercial, and industrial applications be presented in introductory physics courses and since then physics courses and texts have attempted to do this. Usually, however, these are presented from the standpoint of illustrative material and motivation and not as material which will further appreciation. Present texts often, in their introductions, state the main aim of the course in such words as "the appreciation of the place of physics in daily life" but the contents of

the text in most cases does not bear this out. This is brought out by Hurd (21) and Sampson (42) as well as others and the investigation of a few texts will demonstrate this further.

The procedure followed in this thesis embodies some of the suggestions from all the studies above but there are certain modifications that seemed appropriate and necessary. In the first place few of these units had appreciation as their main aim and hence the appreciation technique was not used. The group of appreciation units which were set up in chemistry (38) were based partly on situations in an agrarian community and while these are very worthwhile for certain sections, it seemed better in the present study, to select life situations which would be found in a larger number of communities. Another change which seemed advisable was the method of presentation i.e. the form of units. Some previous units have consisted of mere outlines of subject matter to achieve certain aims, or in other cases they have consisted of a complete discussion of the materials with little or no specific suggestions as to how this matter was to be presented to the class. Usually a separate section is devoted to recommendations as to the teaching methods the author believes would be effective but the material itself requires considerable revision before it can be used as a definite long-time lesson plan. To be most useful it seems that the material should be presented so that the teacher need make only a few modifications before actually carrying out the unit. This has been the plan in the present study.

CHAPTER III - PRESENT INADEQUACIES AND SUGGESTED REMEDIES IN TERMS OF OBJECTIVES

Before discussing the objectives for the units it seems logical to consider what the objectives of the typical introductory physics course have been, their weaknesses, and the extent to which right objectives have been met.

Sampson's (42) conclusions to this effect as applied to chemistry are as follows:

1. There is considerable doubt as to the value of a chemistry course as now taught.
2. The present course is not meeting the main aim i.e. the fostering of a scientific attitude.
3. The present course is doing little to teach the appreciations of chemistry in daily life.
4. There is considerable feeling that appreciation should be the chief aim and scientific attitude secondary.

These are based on a survey of material on the subject, and there seems to be little evidence that the picture in the field of physics is any different. The traditional method of teaching has usually had as its objective a knowledge of the fundamentals and yet at least one report seems to infer that there has been little grasp of these from High School courses. In a study "High School Physics Makes Small Contribution to College Physics." (22), it is pointed out that the tendency of prepared students to do better work is not marked while the possibility of unprepared students doing just as well is more noticeable.

Another aim of many teachers has been the acquiring of an ability to make the principles learned in physics serve him in a better understanding of their various applications, but Stewart's attempt to test this ability showed that 29% of the answers were wrong in their interpretation of life situations. (48).

Others may claim that an introductory physics course will arouse interest which will increase the election of physics in college courses and the effectiveness of these courses. Since previous courses in chemistry and physics have had paralled aims and similar methods it does not seem illogical to expect that studies made in chemistry would show results similar to those to be found in physics. In "Selection of Chemistry in College" (32), the authors point out that High School chemistry does not have much effect on the election of college chemistry. Would not similar studies show that students having taken a course in physics in High School would not have any greater inclination to elect physics in college? It seems equally probable that what native interests a pupil might have in science were dampened by the formal presentation of laws and principals.

Hurd lists the present inadequacies in terms of remedies in "Reorganization of Physics" (19), as follows:

1. Subject matter should be suited to the pupil's needs.
2. Teachers should have better and more specialized training.
3. The aims and objectives need to be well defined.

4. The pupils should have more responsibility and freedom.
5. The scientific method should be used to determine future changes.

This last point was also emphasized by Osborne in "Modernizing our Secondary School Science." (31).

The next task then is to select appropriate objectives. All articles reviewed on the reorganization of the course in physics, recommended the evaluation of objectives as the point of departure in planning a course. The next step found is the determination of subject matter and methods which will realize these objectives or at least the selection of a main objective and suggested reorganization that will accomplish this. In other words objectives must be set up apart from rather than in terms of subject matter.

What then are these objectives? The earliest comprehensive survey of objectives was made by the Commission on the Reorganization of Secondary Education Appointed by the National Education Association in "The Reorganization of Science in Secondary Schools." (5). This commissioner first states the general aims and purposes of science in terms of the main objectives of education as set up by them earlier. (55). They claim that science is especially valuable in attaining six of these cardinal principles; health, vocational efficiency, worthy home membership, worthy use of leisure time, and ethical character.

They point out the elements in science contributing to these. For example, the aim of good citizenship is furthered since "the members of a democratic society need a far greater appreciation of the part which scientifically trained men and women should perform in advancing the welfare of society" (5,p.13) as well as an intelligent appreciation of the services science renders and an intelligent basis for the selection of experts. The specific values of science as listed by this commission are as follows: (5, p.14-15).

1. The development of interests, habits and abilities from opportunities for actual contact with materials that have real significance in the life of man, contacts that result in keen interests, appreciations and powers.

2. The methods of problem solving formed through and firmly associated with the kinds of experiences that arise in common needs.

3. Stimulation - a higher appreciation of pleasure and profit to be obtained by exercise of our abilities. "An appeal to divergent interests and the connection shown with common questions of every day life."

4. Information values - facts, principles, and [illegible] "The measure to which these represent points of view, deepened and intensified powers of insight, methods of procedure, and points of departure for new attempts for further study."

5. Cultural and aesthetic values; appreciations (to be listed later)

The specific habits and abilities acquired through physics as listed by the sub-committee on physics are;

1. Observing accurately significant facts,
2. Developing a methodical plan of attack before beginning an experiment,
3. Developing of system, order, and neatness,
4. Learning to use the hands, eyes, and ears before a book when knowledge of phenomena is sought,
5. Care and intelligence in the manipulation of any tools or apparatus,

From an analysis of literature on the subject between 1910 and 1926 the following aims, functions, values, and purposes are reported; (19)

1. Physics reveals and interprets physical life giving breadth, perspective, and balanced appreciations.
2. It develops rational individuals able to use specific knowledge, skills, interests, abilities, or habits in the better solving of everyday problems.
3. It promotes social and vocational efficiency.

This study also suggests more specific values in terms of knowledge, appreciations, techniques, habits, and interests.

Phillips in "The Aims and Methods of Science Teaching in the Successive Stages of the Secondary School" (34) claims that the objectives of science should include -- a study of the lives of the great leaders who were obliged to make real sacrifices to establish truths, the development of powers of inter-

pretation from material facts, the encouragement of experimentation and observation during leisure time, and the illustration in a lasting manner through projects, some historical experiments or new concepts in scientific discovery.

Berger (3) and a group of students, tried to evaluate and rate these objectives and reports that the knowledge of first importance is that which "gives an insight into the nature and organization of the environment." (3,p.559).

Out of the total of sixty objectives six different appreciation objectives listed by this group received ranks of 5, 10, 13, 16, 26, and 33 in importance. Appreciation aims then are apparently accepted by experts as having a high place among the objectives of science teaching.

The objectives have been set up in numerous ways as seen above but it is necessary to summarize these or restate tham to make it easier to keep them all before us in continuing with the units. Power's set of values seems the simplest for this purpose. (35). He states that science has educational value if;

1. Students acquire an ability to interpret the natural phenominon of their environment.
2. Students acquire an ability to utilize the findings of science which have application in their own experience.
3. Students acquire an understanding of an ability to use the methods that have been used by creative workers in the fields of science.
4. One more evidently should be added; Students acquire a wider field of interest.
   (Added by author).

These seem to be general enough to include all the objectives mentioned previously yet specific enough to have a clear view of the end.

The units to be undertaken however, are to have as their chief aim appreciation objectives. It is obvious that these are included in and closely related to the main objectives but they are more specific since they do not imply skills, abilities, techniques, or knowledge except as secondary consideration. A list of these from several sources include;

1. The appreciation of the benefits of science to medicine, the home, agriculture, industry, and commerce. (19), (5), (3).
2. The appreciation of the universal application of natural law -- cause and effect relationships -- freedom from fears and superstitions -- freedom from ignorant practices. (19), (5), (3), (35).
3. The appreciation of the marvels embodying our commonplace environment. (3).
4. The appreciation of the beauty in nature and natural phenomena. (3), (5).
5. The appreciation of the work of great scientists past and present, (19), (5), (3).
6. Appreciation of the work and method of scientific research. (3), (19), (34), (31).
7. The appreciation of the privilege that living in this age of science involves - the political issue of the problems of power and development. (35).

Stated more generally the main aim of these units is to enrich the pupils' life and experiences and place him in a position to get a thrill from the applications of physics in his daily life.

When an individual responds emotionally to a situation involving effective values which operate only on refined tastes, it may be said that this individual has a worthy appreciation for that situation. (49 p.191). Having selected appreciations as the aim of the units, what is the best method for attaining these? There has not been much written on the appreciation technique although some of the newer texts in principles and methods of teaching do contain sections on the appreciation lesson.

The original work on appreciation is "The Lesson in Appreciation" by Hayward (16), giving Findlay credit for its genesis. The need for appreciation lessons is brought out and some principles to be followed derived. The author states that first impressions are most important in conducting an appreciation lesson since by these, motivation is either positive or negative and the law of readiness acts for or against the purpose. Even when interests are aroused if there is too much intellectual distraction the opportunity is lost. Hayward suggests that extraneous material be omitted, difficulties be prepared for in advance, and the lesson be systematized only in the teacher's mind. He believes that the appreciation lesson is not the time for systematized and formal teaching and the early stages of the lesson are not even the time for technical discussions. There are, however, certain steps to be taken on the part of the teachers.

First the teacher must get himself ready emotionally for appreciation on his part. Next he must consider the immediate preparation of the material to be presented. This must then be given in as informal a manner as possible. In regard to this it is well to keep in mind that likes and dislikes are largely determined by familiarity, habit, and custom. Also aesthetic pleasures are often gained from the grouping together of ideas, the new and strange with the old and familiar in a logical orderly fashion. These steps should be followed by discussion, comparisons, and the formulation of generalizations. A later discussion may include factual or intellectual presentation of the subject matter, but even this must be as informal as possible. Logical order of course is necessary for easy comprehension. The last step should provide an opportunity for individual reproduction and application. In this paragraph I have taken the essentials from Hayward, omitting his misguided attempts at following the

Science offers many opportunities for thrills and hence lends itself readily to this type of lesson. Some may criticize presenting practical applications in this fashion, but in a world which is becoming increasingly commercialized and systematized there seems much to favor the raising of general standards of tasts to an appreciation of natural phenomena and the more delicate adjustment or intricate planning in a commonplace machine. We are daily losing opportunities to see and appreciate primitive nature but man's application of

nature's laws for his own use may be equally appreciated if the senses and emotions are so trained. So far, in this respect, education has failed even in such fields as music, art, and literature where appreciation has been one of the chief aims for a long time.

Strebel and Morehart (49) state there are two types of appreciations -- social and aesthetic. The aesthetic class is fundamentally artistic and inspirational while the social class is a force in the development of good citizenship and ethical character. It is the first class with which these units are chiefly concerned. The suggestion for teaching made by these authors are very similar to those of Hayward. They would however, try to put intellectual understandings first, since these are a prerequisite to the development of appreciations, that is, the new must be explained in terms of the old. Through proper motivation the understandings may be brought about so that appreciations result as well. The best plan seems to be to teach the necessary difficult elements before they are needed or are to be called for in the appreciation lesson since at this time the emphasis should be on emotional responses. These authors believe that the student must actually "live through those emotional experiences the appreciation situation is designed to effect" and hence the elements must not be foreign to life contacts (49-p.199). There must be actual or vicarious participation and the depth of appreciation depends on the degree to which this is brought about.

The following are suggested as criteria for the selection of material for and the presentation of appreciation lessons by Professor Wilson of Boston University.

1. The aims are enjoyment and a permanent field of interest.
2. The field is as wide as human endeavor itself.
3. The procedure should provide an opportunity for initiative and voluntary effort.
4. Profitable and enjoyable use of time and ability should be the immediate end.
5. Success should be judged by:
    - a. The quality of the undertaking.
    - b. The degree of satisfaction attained.
    - c. The permanence of interest.

The above expresses the wider view on appreciation that has been gradually developing since Hayward's first full presentation of its possibilities.

CHAPTER V - PLAN OF UNITS - SUBJECT MATTER AND PRESENTATION.

The final plan for the units is built on the four fundamental premises given by Hurd. (19).

1. The course should add to pupil's knowledge as much as is feasible about the physical world in which we live. so that he may use it in his every day life to make him more efficient socially and vocationally.
2. Subject matter should bear upon his necessities and his experiences in daily life.
3. The method should follow a natural psychological order built upon the pupil's present knowledge.
4. Laboratory, recreation, and demonstration should not be on a definitely divided time basis, but should be dovetailed together in a manner determined by the nature of the task, the purpose in mind, and the facilities at hand.

In considering possible sources of subject matter the writer sought for material which would be most applicable to the aim and at the same time close to experiences in the lives of the pupils, as stated above, to that subject matter which would have somewhat universal application. Because of this, material was not drawn from industries. Only common home applications are used in most cases.. It is obvious that natural phenomina should be the most fruitful source because of its nearness to any pupil's experience and hence much material is drawn from this source. When the possibilities in natural phenomena and practical application in the home had been listed

there still seemed to be a need for selection. The material was finally selected because it seemed to have the most appeal on the basis of: the scope of the material, its nearness to the student's present interest, its nearness to the student's future vocational or social interest, its value in explaining mysterious phenomena or complicated mechanisms and the chance to see the actual working of these in life. Historical and biographical material is also included because of its human appeal and its accessibility. The desirable content on this basis then includes home and natural environmental situations and historical and biographical material. In reference to natural phenomena Power's states that, "Values which come from the interpretation of natural phenomena may be even more far-reaching in their importance to general training than many of those which come from the understanding of application." (35), p.21). This thesis assumes the importance of both types.

As a final check the material which required the comprehension of laws, principles, and theories, not included in the syllabus for physics of the College Entrance Board was omitted. (56). This was done to eliminate any understandings which would be too difficult for the pupils and hence act against the appreciation aim. The units are not necessarily for a college preparatory class. Perhaps the College Preparatory standard is too high. Each teacher must decide what her class is equal to. The use of this syllabus is a general attempt to place the work at the high school level. It is not an attempt to conform with

college board requirements.

In organizing the units certain general principles were followed. The first and most important of these is that the material should be organized psychologically according to the pupil's present knowledge and interests. Peters (33) found that pupils make better gains when applications precede principles and this should be especially true when the applications are close to the pupil's need and experiences. In accordance with this requirement and to make motivation the first step in the appreciation set up, the first material presented in each unit is applications old and new. In some cases this is presented purely as motivation and in others as an introduction which will snow the pupils the purpose and worthwhileness of the undertaking, which is in itself a type of motivation.

Caldwell (50. Hurd (19), Peters (33), and Phillips (34) all advocate stating the units in terms of projects, problems, a definite question, or a proposition - hence the statement of the purpose of each unit usually contains problems or questions which are to be worked through or answered in the unit. These centralizing topics are often carried through before the completion of the unit itself, but the additional material is closely related and adds to the total appreciation.

Since most units will contain such phases as recitation, demonstrations, and laboratory work it seems advisable to set down a few principles followed in planning this part of the work.

Laboratory work is accepted by most educators as an important part of education in the sciences but there is less agreement as to its exact function and place in the lesson. The answer hinges somewhat on the relative desirability and effectiveness of an inductive or a deductive learning procedure. The units given here have elements of both these methods or more exactly they alternate from one to the other. Laboratory work then is not given a definite place in relation to other phases of the lesson but is inserted wherever the need for, and interest in it, would be expected to arise.

In connection with the laboratory work it is suggested that the pupils plan their own procedures after the teacher has put the question or problem before them, and then observe accurately what occurs and deduce logical conclusions from their own data.

Since reports (10) (27) vary as to the relative effectiveness pf Lecture-Demonstration, Experiments, and Individual Laboratory work, a compromise is made. It is suggested that the teacher carry out many of the suggested experiments himself with the pupils directing the various steps.

In so far as possible it is suggested that the recitations be socialized and informal with the pupils making most of the contributions and the teacher merely directing and stimulating thought. The units contain suggestions for the teacher in this function.

The final form for the units in accordance with the above principles and the steps of an appreciation technique is given below.

1. The purpose in terms of specific questions to be answered and information to be acquired.
2. Historical background - how others explained the phenomena, biography, etc.
3. The importance of the application to the home or the place of the phenomena in nature. i.e. its function as a part of our environment.
4. The main principles on which the application or explanation of the phenomena depends. (Subordinated technical materials).
5. Supplementary topics to be suggested to the pupils for further interests and appreciations.

As formerly stated, demonstrations, laboratory work, field trips, problems, and recitations are to be inserted where they will have the most value to the aim of the unit.

In the units the references underlined are ones to be suggested to the pupils as that topic or a related one comes up. In most cases references are not to be given as assignments but merely as suggestions which the pupils may find interesting in the light of what they have already learned or in view of what they could learn from further pursuit of the subject.

The word Diagram in parenthesis indicates that the teacher should draw a simple diagram on the board and use this in ex-

plaining the principles discussed in that part of the unit, unless there are models for that purpose included in the class supplies.

In general the supplementary topics should be given at the end of the unit. If the pupils seem to be particularly interested in some phase of the work related to one or more of the topics the teacher may ask a pupil or group of pupils to report on it to the class. These should never be given as required assignments as their chief purpose is to stimulate further interests and extend the appreciations attained through the unit. If the topics are made formal their real purpose as well as the purpose of the unit as a whole may be defeated.

It will be noted that the units are not all the same size either as to the amount of material that they cover or the time necessary to complete them. This naturally happens because some subjects have less material suitable to the type of unit. Appreciations units must necessarily be informal and flexible and placing them on a time basis would subtract from these appreciation values. Also in some cases units like this are not taken up at all at one time and hence cannot be placed on a time basis. This latter method however, does not seem especially suitable since the insertion of unrelated fact material or too much related fact material or laboratory work will detract from the appreciation aim.

I. Purpose; What is time? How has it been measured? On what does its measurement depend?

II. Historical Background;

A. Outline of introductory remarks:

(1) Time is the third physical concept of which man early became conscious, the others being space and mass. How would you define it? Do you know what rough measures of it early man had?

(2) Early methods and concepts:

a. Thousands of years ago the Egyptians noted that the Nile overflowed its banks at the same season. When they became sure of this they began making a record on a slab of stone of each time it overflowed. They then counted the number of marks from a certain king's rule instead of from the time of Christ as we do. They did not however find a way to figure how long the earth had existed before they began to make records. (17) How do we know the age of the earth now?

b. The Babylonians were interested in the stars and began to notice things about the motion of the sun. At one time the sun traveled toward the north, then it rose high in the sky and at noon it was right overhead and the light part of the days was longer. What time of year was this?

Then the sun traveled toward the south and the days grew shorter. The priests kept records of all this and decided to divide their time so that a year was the length of the sun's trip from farthest north to farthest south. They also saw twelve groups of stars in the sky and that these made a path for the sun around the earth. This path the priests called the zodiac. Here then, was another division, a division for each group of stars. These are the signs of the zodiac; Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricornus, Aquaris and Pisces. See if you can find out what these stand for. Perhaps you would like to read the way astrologers attempt to tell our fortunes using these signs. The priests went further than this. They noticed that the moon's shape changed and that it took about the same time to go from one full moon to another as for the sun to pass through one group of stars. Moon means a measure of time and our word month comes from the word moon. The Babylonians now had years, months, and days but their year was three hundred and sixty days long.

c. The Romans in Julius Caesar's time found that the year actually had three hundred and sixty-five and one fourth days and so made some months longer than others and named the months as we know them now. About fifteen hundred years later Pope Gregory the twelfth established the calendar similar to the one we use now. Have you heard anything about changing from this to a new one?

B. Attempts to measure time:

1. Home assignment; Look up some of these in the encyclopedia or in (25,p.160)(57)(44)(23,pp13-14).
    - a. Clepsydra, the "water-thief," the milk-clock in Egypt.
    - b. Sand glass or hour glass.
    - c. Burning of candles of different lengths.
      Ropes knotted to mark off the hours.
    - d. Signs of the zodiac.
    - e. Astrology . Gregorian Calendar. Almanac.
2. Class discussion of measures of time mentioned in introduction and contributions of students from reading.
3. Exhibit of sundial, hour-glass clepsydra etc.

III. The importance of the measure of time to everyday living. This should be in the form of a discussion with the pupils contributing but the teacher can start them off with such questions as: How could you tell the time of day without a clock? The time of year? Where is the sun at noon in the summer?

IV. Main principles on which the measures of time depend:

A. Astronomy; As mentioned before the sun's apparent motion among the stars which causes it to make a circuit of the heavens once a year was one of the first phenomena noticed by the ancients. This is actually due to the earth's revolution around the sun taking a year to cover the circuit.

The earth's axis continually points in the same direction[1] and if the axis were perpendicular to the plane of the earth's orbit there would be no change of seasons, and day and night would be of equal length everywhere. The axis however, is tilted 23 degrees, 27 minutes away from the perpendicular to the orbit. (Diagram). On March twentieth and September twenty-second the axis is at right angles to the direction of the sun and only at these times are day and night equal the world over. In December the North pole is tipped away from the sun and the nights in the northern hemisphere are longer than the days. The opposite of this is true in June and at this time the northers hemisphere receives the most heat.

The sidereal year is the time taken by the sun in apparently completing the circuit from a given star to that same star again and is 365 days, 6 hours, 9 minutes, and 9 seconds. This then is the true year since it is the time occupied by the earth in completing its circuit around the sun. The seasons depend on the sun's place with respect to the equinox and hence the year used in civil measuring is reckoned from this. At vernal equinox the sun crosses the equator and day and night are equal but the equinox moves yearly about 50 seconds to the west and hence the tropical year is approximately twenty minutes shorter than the sidereal year or 365 days, 5 hours, 48 minutes, 46 seconds. This is the year we use and we make

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[1] THis is not exactlt true because of precession.

up for the additional time by adding an extra day every fourth year (leap year).

The Mohammedans still use a purely lunar calendar having a year of twelve months,containing 354 or 355 days. The moon's apparent motion among the stars takes about twenty-seven and one third days. That is, it revolves around the earth in that length of time while accompanying the earth on its annual journey around the sun. The moon also turns on its axis once in a month and hence keeps practically the same side towards us all the time. (Diagram) Since the moon's apparent path among the stars is faster than the sun's it overtakes and passes the sun at intervals. Since we see the moon chiefly because it reflects light from the sun ,it is obvious that the moon's phases depend on and are caused by her apparent position with reference to the sun. Only the part of the moon towards the sun is illuminated brightly but, we can see the rest because of"earth shine " on it.When the moon is between the earth and the sun its lighted half is away from us (new moon). A week later half of the lighted portion of the moon is towards us and we see a half moon. A week later the whole of the illuminated portion is towards us and we call it the full moon. Betwee new moon and half moon during the first and fourth quarter we see less than half the illuminated portion and have the crescent phase. During the second and third quarter we see more than half of the illuminated portion,gibbous moon. (Diagram)

The earth rotates on its axis once in twenty-four hours, sidereal time, and gives us night and day. The earths rotation has been proved to us in numerous ways, the most famous of which is perhaps Foucault's pendulum experiment. Since we will study another phase of the pendulum later let us consider this experiment. In 1851 Foucaul hung a heavy iron ball by a slender wire about 200 feet long ,from the dome of the Pantheon. A pin was attatched to the ball so that it would just scrape a ridge of sand beneath it as it swung. Foucault optimistically made the ridge of sand in a complete circle. The ball was drawn aside by a cord and held till it came absolutely to rest. The cord was burned, releasing the pin and pendulum and allowing it to swing in a true plane. The pin at the end instead of passing through the sand at the same place each time, cut in a new place with each swing. The floor was actually turning under the plane of the swinging pendulum. If this experiment had been made at one of the poles the pendulum would have disturbed the complete circular area of sand in twenty-four hours. (54,pp.89-104,113-115,81-83)

B. Timepieces:

1. Function of important parts:

As early as 2000 B.C. the CHinese probably used weights to turn the hands on the dial in place of falling water as in the clepsydra. This is found in some clocks today but usually a pendulum or a coiled spring which slowly unwinds takes the

place of the weights. in 1852 Galileo while in the Cathedral of Pisa noticed that the lamps casually set in motion seemed to swing with a regular motion and proceeded to test this observation by comparing the beat of his own pulse with the period of the pendulum. He concluded that since the pendulum was found to swing in regular intervals it could be used in the accurate measurement of time. He later used this discovery in constructing a clock for astromomical purposes. We call this regular vibration isochronism and on this principle many of our present clocks depend.

Technically the pendulum is"any rigid body mounted about a horizontal axis so that it can swing to and fro making vibrations under the influence of geavity". (60,X111,p889) In deriving the laws of the pendulum we consider a hypothetical pendulum consisting of a particle of matter, suspended in a frictionless medium,from a point,by a nonextensible cord supposed to be without mass and swinging in a vacuum.

Experiment: Students at this point shoud be instructed to plan how they could find the approximate relation between the lenght of the pendulum ,the acceleration of gravity,and the time taken for one complete vibration of the pendulum . In other words they are to find the period of the pendulum using a small lead ball and a long fine thread. This should then be carried out individually or by the teacher following the students' directions. It is found that the period of a

simple pendulum is $2\pi\sqrt{\frac{l}{g}}$ where l. is the length of the pendulum and g. is the acceleration of gravity. THis is of course not accurate for any great variation from the hypothetical pendulum mentioned earlier ,but it is sufficient for our purpose and is fairly accurate for a small amplitude of swing.

It is perhaps surprising to find that the period of the pendulum is approximately independent of the amplitude of the vibration i.e. the length of the arc the pendulum bob desribes.

The pendulum,however, was not used in clocks till the seventeenth century. Before this the clock usually consisted of a train or succession of toothed wheels to transmit the motive forses produced by a falling weight or a coiled spring and an"escapement" to regulate the exerting of this motive force with uniformity and requisite slowness. The oldest clock of this type of which we have a description is the De Vick clock in Charles the Fifth's palace in France in 1397. (60,IV,p749)

The power that is stored up in the raised weight or coiled spring is communicated to a series of geared whells which are set revolving. This motion is cut up into successive vibrations by converting the rotary motion into small equal impulses. The last whell of the series is toothed so that it will alternately catch and escape and hence is called the "scape-wheel". (Diagram) There are two common types of escapement mechanism used to convert the rotary motion to a backward and forward motion. One type is called the crown wheel,

the last wheel being shaped like a crown ,another is Dr. Hooke's escapement. (60,1V,p.750)

2. Other important considerations:

a. The balance wheel of a watch is a wheel delicately poised on its axis so that it will naturally rotate,but it is set in vibratory motion by the escapement mechanism and a balanced spring. This spring consists of a coil of fine wire which determines the time of vibration of the balance wheel. One end is fastened independent of the wheel and the other to the wheel near the axis. When the balance wheel is set rotating it uncoils the spring only as far as the elasticity of the spring will allow,then the balance wheel stops for a moment and the recoil of the spring drives it back resuling in a vibratory motion. The invention of this important mechanism is usually attributed to Dr. Hooke who patented it in 1660. (60,1X,p379)

b. It is well known that most metals expand with a rise in temperature ,and in watches and clocks a compensation has to be made for this. The balance wheel of a watch usually consists of two semi-circles held together by spokes at one end of each arc. (Diagram) The rim of the sections consists of two metals, the outer one expanding much more with an increase in temperature. We call this a higher coefficient of expansion. When the temparature increases the spokes lengthen and push the rim outward,but the outside expands faster, and hence tends to cause the wheel to curve inward to a broken circle position.If the metals and dimensions of the two opposing parts

are selected correctly ,the two opposing forces will neutralize each other. We turn to chemistry and metallurgy for this sort of information . (11,p.264)

c. Since the period of a pendulum varies with its length it is important that the pendulum remain the same length,hence compensation must be made for expansion. One method is the mercury compensated pendulum. As the steel or brass pendulum rod expands ,thus increasing its effective length. The pendulum is provided with cups of mercury which has a higher [illegible] coefficient of expansion . The mercury then expands upward so that the effective length of the pendulum is unchanged. (Diagram)

Another devise used is the grid iron compensated pendulum . The pendulum is hung from the center of an inverted U-shaped grid of bars. The inner bars are made of a metal which expands sufficiently to lift the bob enough to overcome the expansion of the pendulum itself. (Diagram) (11,p.263)

It is obvious that metallurgy plays an important part in the accuracy of our timepieces. Metals must be chosen on account of such properties as their coefficients of expansion, non-oxidizing and non-magnetic character,and their elasticity. Physics alone then is not suuficient for the development of accurate measures of time.

3. Laboratory work:

   Students plan out and make a clock which could be used for demonstration purposes in later classes and would show the functioning of such parts as falling weights, the coiled spring, the pendulum, and escapement mechanisms. These models will of course, not be accurate as far as the period of time is concerned but should have a regular vibratory motion. They will illustrate again the main principles used in home pieces and also drive home the importance of the subordinate technical materials.

V. Supplementary topics to be suggested to the pupils for further study:

   A. Date lines.
   B. The absolute measure of time.
   C. New developments in timepieces.
   D. Importance of accurate measure of time to astronomy.
   E. The chronometer.
   F. The age of the earth.
   G. Galileo's life.
   H. Foucault's life.
   I. Famous clocks.
   J. Huygens - The balance wheel and escapement mechanism.

   Possible references (60)(57)(54)(17)(8)(44)(43)(25)(23)(61).

I. Purpose:

To show how man has learned to take advantage of natural laws by applying them in the performance of various tasks in the home, i.e., to appreciate the services of science through simple machines in the home. Do"labor-saving" devices actually save work? What do we gain from the use of these devices in the home? What has science done to increase the efficiency of home-makers? What is work? Are there any simple principles which apply to many of these machines? Is there any beauty and orderliness to be found in these appliances?

II. Background:

Many devices have come as a result of the practical applications of the discoveries of theoretical physicists. There are probably an equal number of cases where man has stumbled on "short-cuts" and aids in carrying out his daily work. This latter is the case with simple machines. Even as a barbarian,man used some of these devices. When man began to be more civilized, and started to build cities, temples and pyramids he had to find a way to carry and lift heavy objects. Two early devices of this period were the crowbar and the wheel. What did they gain by using the crowbar and the wheel? (29,42). If man at this time had stopped his work to determine the laws for these two devices he might have devised other simple devices to help him in his work.

This scientific study, or at least its record and report, was left to Archimedes. Two centuries before Christ, Archimedes set down the law of levers. Leonardo da Vinci, whom you probably know as an artist, made the next advance sixteen centuries later, by stating the law so that it applied to more cases. Another way man learned to take advantage was through the use of the inclined plane. This was studied by Galileo and Sevinus. This principle is applied when piano movers pull a piano up a slanting platform, rather than trying to lift it to the desired position.

The scientific work of these men and others as well, as the trial and error method of man, have given us the simple machines found in our present mechanical world. In fact our most complex machines are not much more than a combination of simple machines and the replacing of human energy by electrical power, water power, and steam engines.

B. Student projects and discussion:

What machines were used by the ancients and our ancestors? Find out what you can about some of these and tell the class about them.

Suggested topics:

1. The Spinning wheel.
2. The Butter-churn.
3. The Well-sweep.
4. The windlass.
5. Archimedes screw.

6. The Battering ram.

III. Importance and abundance of simple machines in the home:

Let us make an imaginary tour of your home. If we are observing, we will see and make use of these simple machines from the time we turn the door-knob till we go out again and lock the door. The hall clock tells us that it is mid-morning and that there should be considerable action in the kitchen. We all have already learned that the clock functions as a timepiece partly because of its system of gears. We enter the kitchen and are immediately asked to open a can. In doing this we are unknowingly applying the principle of the lever. We look around and see a bread-mixer, an egg-beater, a nut-cracker, a coffee-grinder, a meat-grinder, and many other devices that make housekeeping easier. We are getting more observing now and wonder what kind of a device the window lock is. Some one points out the scissors, needles, and pins to you. Pins seem to you too common and simple a thing to be classed as a machine but you will find later that they actually are an application of the principle of the inclined plane. The sewing machine is certainly a complex machine and yet you can come to understand many parts of it. The cellar or garage and the tool chest are examined. Here we find the hammer, the drill, nails, an axe, a vice, a lawnmower. pruning shears, a lifting jack, pliers, and wheelbarrow.

What other similar devices did we miss? All of these are not necessities but they certainly save time, are more convenient, and help us do things we could not do at all by ourselves. What is the gain in using each of these?

By this time you will think of many other things in your own home which should be mentioned. Try to tell the class why these are used in your home. Have you ever thought of some device you wish someone would invent?

IV.A Work and Power:

Before trying to explain these devices it is necesszry to agree on what we actually mean by work and power. When you lift a weight a certain distance you call that work. If you had raised it twice as high you would say that you had done twice as much work. Work then involves two things -- force and distance.The force you exert depends on the mass you lift and the acceleration you give it. Force equals mass times acceleration where acceleration is the rate at which the velocity is changed. It is the push or pull you have to exert to move the mass. You do just as much work lifting ten pounds two feet as you do in lifting five pounds fourfeet, if you lift them both in the same direction. Energy is the capacity to do work, and is always conserved[1]. It is obvious then that you cannot get more energy out of a machine than you put into it. To be philosophical, not even nature lets you get something for nothing. You can lift a mass heavier than the force

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[1] More exactly " mass energy" is conserved. Energy or mass alone are not always conserved. One may be transformed into the other.

you exert or you can lift it higher than the distance through which your arms move. You can't do both at once. In fact, due to friction and other factors you put more energy into a machine than you get out of it.

Until the time of steam engines animals and man did most of the work, and labor was paid for by the day or hour. When machines began to do the work man wanted to know how much these could do in a certain time. The question was how many horses did a certain machine replace? The unit one horse-power means that a machine does work at the same rate as a horse. Watt experimented with draft horses and found that one horse-power equaled 550 foot-pounds of work per second. One horse in one second could lift 550 pounds mass one foot or an amount of work equal to this. This is not exact enough for science. Since Watt invented the first engine that was a practical source of power, the absolute unit is named for him. (11,p.112).

B. Mechanical Efficiency and Advantage.

Due to friction and other factors, machines give out less useful energy than is put into them. By useful energy is here meant the kind of energy for the task it is set to perform. The rest of the energy appears as heat, sound, electrical charges etc. The efficiency of a machine is the ratio of the output to the input. Why then are machines used at all if they actually waste work and are not labor-saving devices at all? How would you raise water from a well with-

out a windlass or a pump? How would you raise a flag to the top of a high pole without a pulley or lift a car without a jack?

It is obvious that machines do have an advantage. In some cases they increase your effective force. In other cases a machine is used to increase speed. In the case of the pulley the advantage is the change of direction of the force applied.

6. Levers:

If we consider the seesaw or teeter we will discover the first principle of the lever. Let us think of two people of unequal weight equally distant from the center of the teeter. The teeter will not balance and if the weight is too unequal it is impossible to teeter at all even by pushing. What can be done in this case?

Laboratory Experiment:

Make a model teeter and balance it. The edge on which it is set is called the fulcrum. Place two unequal masses on the teeter,one on each side of the fulcrum. Make it balance. Notice the distance of each mass from the fulcrum. Try the experiment again using two or three masses on each side of the fulcrum . Can you make two masses on one side balance five on the other side?

From the experiment,can you see any relation between the masses and the distances from the fulcrum when the teeter balances? This is the law of moments. THe moment of

a force is equal to the product of the force and its lever arm, in this case the distance from the weight to the fulcrum. The sum of the moments on one side must equal the sum of the moments on the other side or the teeter will not balance. If the teeter did not balance one end would tip down and the other up, or the board itself would rotate. (Diagram). Facing the teeter let us assume that the moment of force on the right is greater and hence the teeter goes down on this side or rotates in a clock-wise direction. The forces on the other side tend to rotate the teeter in a counter-clockwise direction. When the teeter is balanced the moments of these two forces are equal and the teeter balances. What would happen to the teeter if some one pushed or pulled the teeter up on the right hand side? This moment of force is counter-clockwise and hence should be added to the moments of force on the left. Let us state the lae again then. The lever is in equilibrium or balances when the sum of all the counter-clockwise moments equals the sum of all the clockwise moments.

This principle is applied in the use of a crow-bar. In this case the fulcrum is placed nearer the resistance and with a small force we are able to lift a heavy mass. We sacrifice distance however in order to do this. The mass lifted moves through only a small distance while the end of the crowbar moves through a large distance. We call this a mechanical advantage since the resulting force is greater than the force exerted. If the mass lifted , the resistance, had

been twice as great as the force exerted, the effort, we would call the mechanical advantage two. Sometimes the resistance is between the effort and the fulcrum as in the case of the nut-cracker. The lever arm of the effort is always greater than that of the resistance and hence this type of lever always has a mechanical advantage greater than one. If a nut is hard to crack should you push the nut nearer the fulcrum or nearer the handles? Some levers have the acting force between the resistance and the fulcrum. This means that the effort arm is always less than the resistance arm and the mechanical advantage is less than one. This type is used to gain speed. The wheel and axle is another modification of the lever principle. When you turn a pencil sharpener your arm makes a much larger circle than the blades but the blades exert more force than you do. This same thing is true of the bicycle, the windlass, eggbeaters,+door knobs, [illegible].

A more complicated form is the train of gears. We have already seen how the gears are used in a clock for speed advantage. The two gear wheels of a bicycle are connected by a chain and the gear at the pedal has more teeth. Take an example where there are twenty-four teeth on the front gear and only eight on the back. When the front gear wheel has been turned around once by the pedal, the back wheel goes around three times. The bicycle wheel then turns three times as fast as the riders legs. What combination of gear

would be best for hill climbing?

The pulley used to raise a flag or hoist a heavy weight is really another form of the lever. When we raise a flag we use the simplest kind and merely gain in convenience. We merely change our Downward pull to an upward pull that raises the flag. In hoisting a heavy weight two or more pulleys are used in such a way that there is a mechanical advantage greater than one. (Diagram) The mechanical advantage, neglecting friction and the weight of the pulley, itself is equal to the number of ropes on the pulley that support the resistance. There are many complicated forms of pulleys used but all of these are used to change direction or gain in force, or both. What common uses of pulleys can you think of? What helps you to raise a window and what prevents it from coming down with a bang when you close it?

Which of the various devices in your home mentioned earlier do you know now to be merely levers or combinations of one or more types of lever? Can you name any more?

D.The Inclined Plane:

Galileo derived the laws of the inclined plane from those of the lever. Sevinus solved this problem in another way. This other method is quite simple to understand and very ingenious. Perhaps someone would like to read about it, (29,pp54-55), make some apparatus to use in describing it, and

then explain it to the class.

Experiment:

Using a known weight attached to a spring balance, observe how much force you have to exert to pull the weight up an inclined plane. Measure the height and length of the plane. What seems to be the ratio of the two forces? The height and length of the plane?

Again we find that the effort times the distance over which it is exerted, equals the moment of the resistance. The moment of the resistance is the weight times the actual height it is raised.* If the inclined plane had not been used, this is the work we would have had to do to lift the plane against gravity. We do the same amount of work but it does not take as much force. The mechanical advantage is obviously the ratio of the weight lifted to the force exerted. If however, we knew only the weight to be lifted we could find out how much force we would have to exert by comparing the length and height of the plane. The mechanical advantage is actually this ratio.

Screws, jacks and wedges are really inclined planes or a combination of these and the lever. The screw is an inclined plane wrapped around a cylinder. When the handle o of a vise or jack has been turned around once the jaw or weight lifted has moved through only a short distance, called the pitch of the screw. The pitch is the distance

between adjacent threads or ridges on the screw.The advantage of the jack is the ratio of the circumference through which the handle turns to the pitch of the screw. The use of the jack takes more time but it gives you success. Archimedes was so impressed by the great mechanical advantage of the jack that he boasted he could lift the earth with one if some one would find him a place to stand. (29,p.50)

Needles and pins are actually wedges, or two inclined planes placed base to base. These have a large mechanical advantage but are the least perfect of machines. Much of the energy is wasted due to friction.

These are the main principles which govern the simple machine as it is used in your home. It would be more exact to say that they govern perfect machines. Due to friction and other forces none of our machines are really perfect. Look around again and see how many more devices you can find. Build up a list of these as you know them and make a chart showing the principles operating. Perhaps some of these are broken or don't work well and you can fix them or at least tell what is wrong. In buying some of these devices you know what to look for so that you will take the most advantage from their use. You may even make some of these for use at home.

Machines have been very helpful to man but as soon as

he learned the principle of their operation he began to look for some other device that would actually do his work for him. This was found in wind-mills, water-wheels, steam engines, and electric motors. Even with these man cannot sit idle for he must pay the people who build and run these and hence do some kind of work himself. We are however, getting machines which take less and less of man's time and energy.

V. Suggested "Projects" and Further Reading;"

a. Sources of power besides man power.

b. The steam engine of Hero of Alexandria.

c. The building of the Pyramids by the ancients as compared with the way they could be built today.

d. Life of Watt, Archimedes, Sevinus, or Leonardo da Vinci.

e. The beauty an artist like da Vinci could see in machines.

f. The possibility of perpetual motion machines.

g. The hydraulic press.

h. Water-wheels.

i. The worm-wheel.

j. Steam turbines ((47,pp.89-94).

k. Machines used in Bible times.

l. Machines used in colonial times.

m. What invention at this time would do the most to change the present use of machines?

n. Read Chapter 42 "This Mechanical World."
Morton Mott-Smith (29,pp42-60).

o. Balances.

p. The Work of the Bureau of Patents

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Library

I . Purpose:

What makes the lightning? What makes the thunder? The rain? What is electricity and what relation does lightning have to it? How do lightning rods function?

II . Historical Background:

The ancient Greeks and Romans believed that Jupiter (Zeus) in Mount Olympus caused thunder and lightning. They thought of him as riding in his thunder-car, hurlthunder bolts, and lashing those who displeased him with lightning. They also had a goddess of lightning, Minerva (Athene), who controlled the storms and brandished the thunder bolts. (13, p.52-56).

We know now that lightning is caused by an electrical discharge. In fact we call thunder storms "electrical storms." The Greeks however, knew nothing of electricity till 600 B.C. when Thales noticed that rubbed amber attracted some light objects to it. Our word electricity comes from the Greek word meaning amber. They believed the attraction was due to a spirit or soul sleeping in the amber which could be awakened by rubbing it. Three centuries later Theophrates recorded the discovery of a second substance with similar properties but the knowledge of electricity was practically at a standstill until 1600 A.D. Up till this time

the study of electricity would include only the observation of four phenomena; the lightning flash, the brush-discharge known as St. Elmo's fire, the electric eel, and the amber phenomina of Thales. (11,p.330).

St. Elmo's fire, the light seen during thunder storms at the top of masts and spires, is explained in the myth of Castor and Pollux. During a storm at sea Orpheus played on his harp and prayed to the gods, and when the storm had ceased stars appeared on the heads of the brothers, Castor and Pollux. (13m p.83) Hence they came to be honored as the patrons of voyagers. To this day these lights are considered by some sailors as a sign that they have nothing to fear from the storm. (80,11, 661). St. Elmo is the Saint appealed to by the sailors on the Meditteranean during a storm.

III. Importance and place in present life:

We know now that lightning is connected with electricity. The earlier work of Gilbert, Gray, Faraday, Franklin and others laid the foundation. More recent experimenters have shown us how to make electricity do much of our work. Make a list of examples in your home where this is true. Although we can explain lightning, we have not yet learned how to harness it and turn it to our advantage. We do however want to know how to protect ourselves from it and hence the development and study of lightning rods and insulation.

A simple article in this connection is "Why it is Unsafe to Swim Near a Pier During a Thunderstorm." (53).

IV. A. Electrification:

At the time of Dr. Gilbert, often called the "Father of Electricity and Magnetism," people believed that certain diseases could be cured by applying magnets to the body. Dr. Gilbert wished to separate superstition from fact and began to study electricity and magnetism. He reported in 1 1600 that he had found other substances besides amber and silk which produced the same effect when rubbed together. He called the effect "electrification" and the substances, "electrics." He was unable to electrify some substances and these he called "non-electrics." Gray (1729) later found that all substances could be electrified if insulated properly. Gilbert failed because he did not know that electric charges can flow from one body to another. Bodies through which electricity can flow readily we call conductors. The substances Gilbert called "electrics" were actually non-conductors and those called "non-electrics" were really conductors of electricity. Name some conductors and non-conductors that are commonly used because of these properties.

Demonstration experiment: Suspend a charged ebonite rod by a thread. Bring up another charged ebonite rod. Bring up a charged glass rod. Over a hundred years after

Gilbert, Dufay found that there were two kinds of electricity. He called the kind produced on glass when rubbed with silk vitreous electricity and the kind produced on sealing wax when rubbed with flannel "resinous" electricity. One often hears that opposites attract. What is the case here? The law of attraction and repulsion is the first law of electricity at rest. The same is true of magnetic poles, but positive and negative charges may be separated very far.

B. Theories of Electricity:

Dufay postulated the existence of two electric fluids which could be separated by friction and which neutralized each other when combined. According to this a neutral body would contain equal amounts of this fluid; a positive body, an excess of positive fluid; and a negative body an excess of positive fluid. Ref.

Franklin proposed a one-fluid theory and called the two types of charges positive and negative. He assumed that all bodies contained this electrical fluid but that positive bodies contained an excess of it and negative ones had less than the normal amount. This is similar to our popular concept of heat and cold. There is actually only one fluid, heat, but when we speak of the lack of this we say a body is cold.

The present theory, the electron theory, is some-

what like both of these theories. In the accepted theory all matter is thought to be made up of atoms and these in turn are made up of positive and negative charges or particles. The atoms are somewhat like our solar system with a central of positive charge as the sun and electrons or negative charges as the orbits. (Diagram). The electrical attraction between the protons and the electrons holds the electrons in their orbits just as the force of gravity between the sun and the planets holds in their orbits.[1] Protons and electrons are like the two fluids in Dufay's theory but electrons are the only ones that are capable of moving and hence there is actually only one fluid. This theory differs from Franklin's one-fluid theory however in that the fluid that actually moves is negative, not positive. Conductors according to this theory are substances in which some electrons are comparatively free to move and insulators are substances in which they are not free to move.

C. Induction and the Distribution of Electrical Charges on Conductors and their Discharge:

Demonstration Experiment: Show the charging of an electroscope by induction. When a positively charged body is brought near a conductor the free electrons are attracted to the nearer end of the conductor leaving the other end positively charged. If a negatively charged body is brought near a conductor the negative electrons are repelled to the farther end and hence the near end is left pos-

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1. This explanation hinges on the Bohr theory which is not now accepted. It is however important from the historical standpoint and useful in explaining this type of material.

itively charged. When an inducing charge is removed the conductors become neutral again because of the mutual attraction in the conductors.

THe electrical density of the is greatest on points. THis is so great that the surrounding air becomes ionized. THe molecules of the air lose electrons and are left positively charged and the free electrons attach themselves to neutral molecules giving them a negative charge . Air thus ionized is a good conductor. From these facts it is possible to explain the discharging effect of points. One set of ions in the air is attracted to the point,gives up its charge,and neutralizes it while the other set is repelled. Electric charges are found on the outside surface of hollow conductors unless within these conductors there be a charged insulated bidy. Faraday knowing this ,placed himself and an electroscope in a box covered with metal foil. This box was electrified sufficiently for long sparks to jump from its outside surface and corners, yet there was no effect on the electroscope or Faraday. (11,p.341) THis principle is used in protecting physical apparatus from electrical disturbances.

D. Lightning and Lightning Rods:

FRanklin,knowing the effect of points on conductors in discharging bodies and believing that lightning and the electric spark were identical proposed his famous kite experiment to test this hypothesis . At the end of the kite string he tied a key and a silk ribbon. He held the kite

by the ribbon to prevent any charge that might occur from passing through his body to the earth. During a lightning storm Franklin obtained sparks,similar to those of an electric machine,by putting nis knuckles near the key. Lightning,he concluded, must be a simultaneous discharge from many electrified drops towards numerous spots on the earth's surface or a similarly electrified cloud at a distance.

Lightning rods actually attract the lightning and hence the house is more likely to be struck. When the flash does occur,however, its enegy is dissipated by the lightning rod and the charge is conducted to the ground. As a charged cloud, positive for example,passes over a house it induces a negative charge on the house,the earth,and nearby objects. The higher these objects are the greater will be the density of the induced charge. A flash occurs when the attraction between these two opposite charges is great enough to break down the medium between them. If this occurs a series of sparks jump across and there is the flash of lightning. A lightning rod extended high above the house with many sharp points on it will allow the induced charge to leak off and hence prevent the flash. The rod must be insulated from the house and must be well grounded.

The average thunder-cloud has about twenty coulombs of electricity stored up at a pressure of from one to five billion volts. It is this great pressure which makes the discharge so spectacular and destructive. THis is especially powerful due

to the time-rate at which energy is liberated,since the flash lasts only a fraction of a second. The thunder which accompanies an electrical storm is due to the explosion caused by the sudden expansion of heated air in the path of the discharge and the roll is due to reflection of the sound from hills and clouds. Often the thunder travels high above the observer and frequently one sees the lightning and does not hear the thunder. Do you think that the distance of the storm can be estimated from the loudness of the thunder?(Ad.2,)

E. The Precipitation of Rain From the Clouds:

Demonstration Experiment: Water is thrown from a glass tube like a small fountain. When a charged ebonite rod is brought up the water ceases to scatter in a fine spray. When the rod is brought nearer the water scatters again but falls in much larger drops than originally. When the rod is taken away the stream goes back to its original form.What is the magic power of the ebonite rod? It is electrified and acts on the drops cuacing them to attract each other or repelleach other. This is the reason that rain drops during a thunder storm are apt to be large. THis is not a full explanation but we have seen the effect of a charge on the spray and know that the situation is much the same with a thundercloud during an electrical storm.(Ad. 2,p.88-100) (12)

V. Suggested topics for Further Study and Additional references:

a. Artificial lightning(59)
b. Piezo electricity
c. Pyro electricity
d. Electric machines
e. Electron theory
f. Leyden jar and condensers
g. Gilbert,Dufay,Franklin,Faraday,and Gray- (Life andWork)
h. Things lightning does and doesn't (58)
i. Statistics on losses from lightning
j. Safety in a thunder storm
k. Electric wind
l. Insulation
m. Electroscope as a measure of the charge and its sign
n. Total electric output of lightning in a year (Ad.2,)

I. PURPOSE:

How did our world begin? What is its shape? How old is it? What do we know about its atmosphere? How large is it? Why and how does it move? What keeps it from flying off into space? What can we find out about the inside?

II. HISTORICAL BACKGROUND:

A. Ancient Concepts:

The Greek poets describe the earth as a flat disc with their own country at the center. They thought it was divided in half by the "Sea," the Mediterranean. According to them the "River Ocean" flowed around the earth and all the rivers emptied into it. The Dawn, Sun, Moon and Stars were thought to rise out of the ocean, pass over the earth, and then be borne back to the east again by the sun-god in his "flyingpboat." (13),pp.74-75). The Greeks and Romans had numerous concepts of the world. Do you remember hearing of any of these? (13,37-38)

B. The Advance of Concepts:

You learned in history probably that at the time of Columbus people thought the earth was flat and that he first demonstrated that it was round. Actually centuries before Columbus there were those who maintained the earth was round. The Greek, Pythagoras, twenty centuries before

this was probably the first of these, but he did not suspect that it rotated. He imagined that the earth was a globe floating in space at the center of the universe and that the stars were attached to a larger sphere which turned around it. Heraclides two centuries later was probably the first to realize that the earth itself rotated. The simplest proof of this is the Foucault Pendulum Experiment which we have already studied. A little later Eratosthenes measured the size of the earth. A similar method is still used.. He reasoned that if the earth was flat the sun should be directly overhead at the same time everywhere, but he did not find this to be the real case. When the sun was exactly overhead at Syene it was seven and one fifth degrees from this at Alexandria. The earth then actually curved a fiftieth of a whole circle for this distance. Multiplying by this distance he estimated that the earth was 24,662 miles around. This result is not much different from more accurate recent determinations. (25 p. 8).

The biggest fallacy in the ancient's belief was their egotistical insistence that the earth was the center of the universe. Two thousand years ago Aristarchus put forth the idea that the earth revolved around the sun. Eighteen hundred years later Copernicus published his famous work giving a similar theory. This idea was little accepted until Galileo and his successors proved it through the use of the telescope. The science of astronomy had to wait for

B. If possible show movie "The Earth and Its Rocky Crust" (41, p.121).

IV. What we know and believe about the earth and how science explains these facts and theories:

When we want to study a child we usually ask her who her mother is, how old she is, what she weighs and numerous other questions. This is what we will do in the case of the earth. We speak of it now as "Mother Earth" but there was a time when it didn't exist and also a time when as a child we we couldn't have lived on it.

A. Origin, Early Youth, and Age:

1. All newer theories as to the origin of the earth start with the hypothesis that it was once a part of the sun. We do not know exactly how long ago this took place or how it separated. The first to attack this problem was the philosophers including Kant and Swedenborg. LaPlace in his "Nebular Theory" suggests that the earth broke off from the sun when the sun was still merely an unorganized, incompact, mass of gas. As this nebula revolved the planets were supposed to have been thrown off in the form of rings. When the sun was no longer near this ring it cooled into a globe and became an independent body. As the sun revolved and contracted, ring after ring was thrown off and new planets were formed., each one revolving in smaller and smaller orbits

the development of the telescope.

C. OTHER CONCEPTS:

Many other men contributed to our present knowledge and to get a real idea of the difficulties and complexities this involved, we should read further. These can be found in an encyclopedia, astronomy books or the following: (29)(23)(25)(24).

1. Pythagoras
2. Aristotle
3. Ptolemy
4. Kepler
5. Ticho Brahe
6. Bruno
7. Newton

III. Our earth, what we have observed about it, and the importance of some of its characteristics:

A. Pupil discussion of what they know already: The teacher can start this off by asking such questions as: What can you observe about the earth? Why is there life on our planet and probably not on any others? What would happen if the earth did not rotate? What if it did not revolve around the sun? How did it begin?

than the last. The chief objection to this hypothesis is the fact that the planets possess much more rapid motion than could have been given them by any motion the sun might have had. The quantity of motion of a moving body is its mass times its velocity and is commonly called momentum. The planets have 98% of the momemtum of the solar system yet they only have one seventh of one percent of the total mass. It seems hard to believe that the momentum would be distributed so that the sun which is approximately 745 times the mass of the planets should get only 2% of it. The obvious source of momentum should be the sun and yet the sun could not have supplied it so generously to the planets. (26)

It is now thought that the force which gave birth to our earth was the attraction of a passing star. It seems natural in a system containing over a hundred thousand million stars in motion that one would pass close to an other. We can see in our own case what the effect of this would be. The moon raises tides on our earth and yet it is only one eightieth the size of it. A star even if no larger than our earth would have a mass 24,000,000 times that of the moon and would rise proportionately greater tides. This attraction is due to gravity which we will discuss later. It is obvious at this point however that a star passing as near to the sun as the moon is to us, would raise large "mountains" of gas on the sun. The assumption is that as the star passes the sun the "mountain" is attracted in the same direction i.e.

it trails the star. Finally the star no longer affects the "mountain" but by this time the raised mass has enough motion of its own to overcome the tendency to fall back into the sun. This force is called centrifugal force and is the force which causes mud to splash off your tires when you spin the wheels of your bicycle vert fast. The raised "mountain", now an independent body, breaks up into planets which continue to circle the sun at varying distances. The parts of the mass nearest the star will be farthest from the sun and have larger orbits.

Others believe that the material was first in many little planets which finally collected and grew into the present planets. The exact situation is still not certain but we are fairly sure that the earth was originally a part of the sun. There are at present eight known planets revolving around the sun and there are two between us and the sun. A question we might ask at this time is; Wouldn't there be other examples of a "sun" and a passing star originating other solar systems and worlds?

2. Our next question is, what happened to the earth after it got free from its mother's apron strings? Throughout the earth's existence natural forces have changed its surface appearance and characters. Just as in the case of persons heredity and environment both play an important part in developing the character of the earth.

Jeans and others believe that the earth has passed from a gas to a liquid,to a solid during its existence as a part seperate from the sun. Some believe that it was built up of already soilidified particles,but let us consider the first assumption. As the earth began its existence the lighter substances floated upwards and the heavier ones settled further into the center of the earth. AS it cooled it liquefied and then solidified on the surface. By the time it had solidified the process of seperating the light and heavy substances was qite well advanced. The outer surface cooled first and hence solidified first. THis made a crust over the surface but the interior was still liquid or gaseous. As the inner substance cooled,contracted,and solidified the crust could not support itself and hence crumpled in some places. What kind of scenery would we have if the earth's crust could have contracted evenly? The earth has not yet finished this process. The center is probably still liquid. Earthquakes are evidences that this is true.

3. These changes give us a clue to the age of the earth. The earth itself shows many signs of its age but the science of interpreting these records is very young.

Geology gives us one method. If we can estimate the time required to lay down stratified rock as it is found on our earth we will be reading one of the records. THis has been done and gives us a fairly good approximation of its age.

Another method gives the age of the earth from the time it has had a crusty surface. The oceans began at this time. We all know that the ocean contains salt. Chemistry tells us the amount of salt in the ocean. Chemistry, physics, and geology combined tell us how long it would take for this amount of salt to be formed and carried to the sea. At the beginning of this century geologists ,by these two methods estimated the age of the earth at 100,000,000 years but by the same methods they have extended this to 300,000,000 yrs.(45)

These methods are not entirely accurate and astronomy and physics have also tried their hand at finding the age of the earth. Through astronomy and mathematical considerations it has been found that the orbit of the earth changes following certain laws. The time needed for the orbit to have its present form can be calculated and the age of the earth estimated. This gives us a rough value of two thousand million years. (23,p.146)

The most accurate clock to be found is provided by radio-active substances. Some elements such as Radium and Uranium disintegrate at a constant rate. Uranium changes from one element to another till finally it becomes lead. In seventy million years one per cent of uranium will be changed to lead. Many radioactive minerals in the earth have been analyzed for their percent of uranium and lead,and from these the age of the earth is easily determined. The final estimate from these methods is two thousand million years. (45)

Having found the earth is at least a thousand million years old, other questions arise. How long will it live? Where does the sun get the energy it has been giving to us all these years?

B. The earth's rotation, shape, and size:

We already know that the earth rotates but we have not considered what effect this has on its shape. The earth has been found to be 24,819 miles from pole to pole, and 24,902 miles around at the equator. This, and an extention of Foucault's pendulum experiment show us that the earth is flattened at the poles. Centrifugal force keeps the earth from falling into the sun but it also causes the oblateness of the earth. The earth's rotation on its axis gives the material at the equator a tendency to fly off into space. This would happen if it were not for the pull of gravity. The force is great enough however, to cause the bulging of the earth at the equator. Could you jump any higher at the equator than at the poles?

C. The earth's revolution, gravity, and mass:

Newton's law of gravitation states that every particle of matter attracts every other particle of matter with a force which varies directly as the mass of the particles and inversely as the square of the distance between them. This is sufficient to explain the motion of the planets in their orbits. The sun has a mass 332,000 times that of the earth and hence it has a great gravitational pull. The speed of the

earth and the distance from the sun is just sufficient that the force of gravity is enough to keep it moving around the sun in its orbit. Originally the orbits were thought to be perfect circles and there were some difficulties in working out an orderly solar system. It is now known that the orbits are slightly elliptical. This means that at some points in the earth's orbit around the sun it is nearer the sun and goes faster. What other manifestations of gravity are found in this discussion of our solar system? The sun is approximately 93,000,000 miles away and the mass of the earth is approximately 6.6 times 10.21 tons. (100,600) The mass is found by comparing the attraction which the earth exerts on a body on its surface and the attraction of a body of known mass for this same body. What do you now think of the possibility that Archimedes could lift the earth with a jack? (29,200-203).

The force of gravity on the moon and Mercury is not sufficient to retain any atmosphere. Venus has sufficient gravitational pull of its own but there is little or no oxygen in its atmosphere. How would you like to live on one of these? The earth keeps its supply of oxygen partly because plant-life is a sort of "oxygen factory.

V. We have not answered all the questions about the earth, nor has science. Some of the following material will help us to answer more of these and also give us more interesting details.

Possible sources: physics text, astronomy text, encyclopedia, and (23)(24)(25)(26)(29)(45)(Ad.3) (Ad.4)

a. Eclipses

b. Temperature of the earth.

c. The sun as a source of energy.

d. Further geological determination of the age of the earth.

e. Telescopes.

f. Earthquakes -- the cause

g. Ptolemy's theory of cycles and epicycles.

h. Life and origin of other planets

i. The various stages of animal life since the beginning of the earth.

j. The tides caused by the moon.

k. The future of the earth.

CHAPTER X - GENERAL RECOMMENDATIONS FOR USE IN TEACHING.

There are a few suggestions to be made on the teaching procedures which seem best adapted to these units presented in this thesis. Most of the suggestions are anticipated by previous statements of the present inadequacies and suggested remedies, but it seems advisable to state them more specifically.

Perhaps the most difficult part of the appreciation technique is the proper handling of related technical material, and it is in this phase of the work that the teacher is most apt to lose sight of the appreciation aim. The units are not to be considered motivated drill or knowledge units. They are appreciation units in which technical material does appear but not for emphasis or drill. Appreciation cannot be thought of as a by-product of these units. The emphasis must be on the actual attainment of appreciation as an emotional response. Mastery of technical materials is not necessary to enjoyment, but the skillful teacher can show how these details contribute to it. According to Hayward "The appreciation lesson is not the time for the systematic and formal teaching of techniques --- and the early stages of the lesson are not even the time for technical discussion. (16,p.21) The introduction of technical materials in a formal way tends to detract from the desired emotional appeals. Since drill is most applicable to factual learning it has no place here.

Motivation is an important step in all teaching techniques, but appreciation units should be in part self-motivating. The teacher can, however, take advantage of the law of readiness by keeping a bulletin board posted with popular science material. The students should be encouraged to add to this and to read popular science magazines. In this way there will be continuous motivation, not just motivation when the teacher needs it for a certain unit of work. The teacher should also follow science, and science educational periodicals and add to the original materials of the units continually. The historical background and the importance of the material in each unit in the student's own life should also be a means of motivation. Educational films will increase motivation and add to appreciation.

The additional references and suggested topics should provide for ~~four~~ individual differences of ambitions, interests, and abilities. This seems a sufficient provision since mastery of knowledge is not the aim of the units. Supervised study seems unnecessary for this type of material unless it consists of a period devoted to helping pupils with individual topics or experiments which they wish to develop and carry through.

At all times the teacher should follow the pupil's leads and let the pupils do as much of the work as possible. When pupils ask questions about or mention a certain topic let it

be their privilege to develop this and present it to the class. The additional references and topics are given at the end of the unit but should be introduced at any point in the lesson that they may be called foe. Pupil "projects" such as independent experiments, the making of models and apparatus, and the construction of useful material for use at home or in demonstration experiments should be encouraged.

The unit should be used as the basis of assignments but these should never be required assignments. Class questions should arise chiefly from the pupils and questions that the teacher asks should never be of the factual type. The teacher's questions should be devised to make the pupils think ahead and to direct their thinking. In general tests seem unnecessary but if the teacher is using this type of procedure for the first time a test can be made of its effectiveness. Questions for this purpose should not be factual but should be designed to discover the pupil's emotional responses to the unit. The following are suggested questions to show the type that might be used for this purpose, based on the unit on lighting:

1. What part of this discussion did you like best? Can you give any of the technical details connected with it? [This is not to be graded but is merely for the teacher's use in building up her further plans.]

2. Had you ever wondered about these things before and asked questions? Have they been answered? Have you any more similar questions?

3. Try to explain the lightning storm to a ten-year old including only what interests you the most.

4. What would you consider the best insurance against lightning and why?

5. Are you afraid of lightning storms still? Do you think you will enjoy the next one?

In the final analysis the failure or success of appreciation units depends on the attitude of the teacher. Any attitude that inspires lecturing or drill is out of place. The teacher must first have an appreciation of the material to be presented and the ability and desire to transfer this emotion to the pupils.

CHAPTER 11- SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS.

This thesis has for its purpose the development of a technique for the setting up of appreciation units in Physics and the presentation of a few sample units to show how an appreciation of physics may be given to pupils through material from natural phenomina, and practical applications in the home.

As an introduction, a survey of desirable objectives of a physics course on the Secondary-School level was made and the appreciation aim pointed out as one which needed further consideration. The appreciation aim was more clearly defined and amplified, and a discussion of the techniques to attain this included. The desirable steps of this technique were found to be: motivation, provision for exposure, provision for further growth in the field, and the treatment and subordination of necessary technical materials.

Practical applications in the home and natural phenomina were chosen as the sources of subject matter since they were close to the pupil's experiences and seemed most likely to have the desired appeals.

A technique for the presentation of this material for the teachers' use was then devised and the following general plan given: statement of the purpose, historical background, importance to the student's life, main principles and technical materials, and supplementary topics.

As a final step four sample units were set up on the appreciation basis and general recommendations for their use included. The unit titles are as follows:

1. Times and Timepieces.
2. Lightning and Static Electricity.
3. Ways of taking advantage.
4. Our Earth and Sources of Energy.

The conclusions to this type of thesis are chiefly restatements of the basis for such an attempt. The statement of these with reference to the sources of evidence are as follows:

1. The present typical High School Physics course is of doubtful value. (5)(48)(50)(22)(55).

2. The present aims in terms of subject matter, college achievement, the development of scientific attitudes, and the ability to apply principles learned, are not being met. (48)(50)(22)(1)(32).

3. A course of study should be adapted to meet the pupil's need rather than college requirements. (33)(56)(5)(7)(19)(30)(15).

4. Appreciation of physics in the student's daily life should be one of, if not the chief aim in a High School course in Physics and this is not being met. (34)(3)(5)(35)(138)(42)(55)(37).

5. A course of study could and should be set up for this purpose. (34)(19)(30).

In part these conclusions are recommendations. The writer also recommends that the technique for this type of unit be developed and perfected further and with this established, a comprehensive program for the development of further units planned. Material from industrial, home, and community applications as well as natural phenomina is abundant enough to provide subject matter for an infinite number of units. Further helpful contributions could be made by developing additional units and it is hoped that individual teachers will do this for their classes. When a sufficient number of units have been developed and organized it would seem advisable to plan a whole course based on them for those not definitely attempting to meet college entrance requirements.

The final ideal situation would be met if college entrance requirements should be made flexible enough that all introductory science courses on the high school level might be of this general type, and there is some tendency towards this flexibility already. This would mean such a course would act as an "orientation course" for all and that suggested practical courses for special groups would be given separately. Liberal and useful are no longer hostile terms in educational theory and it seems only a matter of time before they are considered favorably in educational practice.

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